I, the undersigned, who have prepared English translation which is attached herewith, hereby declare that the aforementioned translation is true and correct translation of officially certified copy of the Korean Patent Application No. 10-2000-0054918 filed on September 19, 2000.

Translator: _____
Eun-Jung CHOUNG
Date: November 13, 2006

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Applicant(s)	SAMSUNG ELECTRONICS CO., LTD.

APPLICATION FOR PATENT

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TITLE: LIQUID CRYSTAL DISPLAY PANEL

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Submitted herewith is an application identified above pursuant to Article 42 of the Patent Act.

[ABSTRACT OF THE DISCLOSURE]

[ABSTRACT]

The pixel electrode has openings extending in the transverse direction and X-shaped projection members. The X-shaped projection members are formed by the X-shaped member thereunder, and portions of the gate insulating film and the passivation film on the member. The openings are formed in portions which divide the pixel electrodes into three rectangular portions, each X-shaped projection member lies in the respective portion which the rectangular portion into four areas. An area divided by the X-shaped projections, the openings, and boundary of the pixel electrode has a planar shape of equilateral trapezoid. The present invention reinforces the bend and the splay arrangement of the liquid crystal molecules so as to improve the response time.

[REPRESENTATIVE FIGURE]

FIG. 1

[INDEX]

liquid crystal display, response time, projection, opening, area

[SPECIFICATION]

[TITLE OF THE INVENTION]

LIQUID CRYSTAL DISPLAY PANEL

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIG. 1 is a layout view of an LCD panel according to a first embodiment of the present invention;

FIG. 2 is a sectional view taken along line II-II' in FIG. 1;

FIG. 3 is a layout view of an LCD panel according to a second embodiment of the present invention;

FIG. 4 is a sectional view taken along line IV-IV' in FIG. 3;

FIG. 5 is a layout view of an LCD panel according to a third embodiment of the present invention;

FIG. 6 is a layout view of an LCD panel according to a fourth embodiment of the present invention;

FIG. 7 is a graph showing voltage(V)-transmittance(T) characteristics of the LCDs according to the first to the fourth embodiments of the present invention;

FIG. 8 is a graph showing time-transmittance characteristics of the LCDs according to the first to the fourth embodiments of the present invention;

FIG. 9a shows a matrix of pixels according to a preferred embodiment of the present invention when the distance between a data line and a pixel electrode is 5㎛; and

FIG. 9b shows a matrix of pixels according to a preferred embodiment of the present invention when the distance between a data line and a pixel electrode is 10㎛.

[DETAILED DESCRIPTION OF THE INVENTION]

[OBJECT OF THE INVENTION]

[FIELD OF THE INVENTION AND CONVENTIONAL ART IN THE FIELD]

The present invention relates to a thin film transistor array panel for a liquid crystal display (LCD).

Generally, an LCD includes an upper panel having a common electrode and a plurality of color filters, a lower panel having pluralities of TFTs and pixel electrodes, and a liquid crystal layer between the two panels. The pixel electrodes and the common electrode are applied with different electric potentials to generate electric fields which change the alignment of liquid crystal molecules to control the light transmittance, thereby displaying images.

However, an LCD has a serious disadvantage of its narrow viewing angle. To overcome this disadvantage, various techniques for widening the viewing angle are suggested. Among them,

there is a technique that the liquid crystal molecules are aligned perpendicular to the upper and the lower panels and pluralities of openings and/or projections are provided in the pixel electrodes and a common electrode facing the pixel electrodes.

In a conventional technique directed to the openings, the openings are provided in both the pixel electrodes and the common electrode to generate fringe field. The tilt directions of the liquid crystal molecules are adjusted by using the fringe field. A conventional technique related to the projections adjusts the tilt directions of the liquid crystal molecules by using electric fields which are distorted by the projections. In a European Patent EP 884 626 A2, various features of the projections are suggested.

Although the viewing angle of the LCD is improved as suggested by the above conventional techniques, the response time of the liquid crystal molecules is not still improved so that it is difficult to display dynamic images due to afterimages.

It is an object of the present invention to improve the response time as well as the viewing angle of an LCD.

[TECHNICAL TASK OF THE INVENTION]

It is an object of the present invention to improve the response time as well as the viewing angle of an LCD.

[CONFIGURATION AND OPERATION OF THE INVENTION]

A liquid crystal display (LCD) panel according to the present invention comprises an insulating substrate, a pixel electrode formed on the substrate and having a plurality of openings, and X-shaped projections formed on the substrate. An area divided by the X-shaped projections, the openings, and boundary of the pixel electrode has a planar shape that a corner at the center of X-shape of the first area divided member is chamfered. The opposite sides of the chambered corner may be convex. The opposite side may form a circle when the radius of curvature of the opposite sides is extended.

The LCD panel according to the present invention comprises an insulating substrate, a pixel electrode formed on the substrate and having a plurality of openings, and X-shaped projections formed on the substrate. An area divided by the X-shaped projections, the openings, and boundary of the pixel electrode has a planar shape of acute angle. The X-shaped projections may be positioned under the pixel electrode and a surface of the pixel electrode is protruded by the projections.

The LCD panel according to the present invention comprises a first substrate, a pixel electrode on the first substrate, a second substrate facing the first substrate, a common electrode on the second substrate, a first area divided member formed on at least one of the

first substrate and the second substrate and having X shape, and a second area divided member formed on at least one of the first substrate and the second substrate. An area divided by the first area divided member, the second area divided member, and boundary of the pixel electrode has a planar shape that corner at the center of X-shape of the first area divided member is chamfered.

The LCD panel according to the present invention comprises a first substrate, a pixel electrode on the first substrate, a second substrate facing the first substrate, a common electrode on the second substrate, a first area divided member formed on at least one of the first substrate and the second substrate and having X shape, and a second area divided member formed on at least one of the first substrate and the second substrate. An area divided by the first area divided member, the second area divided member, and boundary of the pixel electrode has a planar shape of acute angle. The first area divided member may be formed on the second substrate and has a projection shape, and the second area divided member may be an opening formed in the pixel electrode. The first area divided member and the second area divided member may be openings formed in the pixel electrode and the common electrode, respectively. The first area divided member and the second area divided member may be formed on the first substrate, the first area divided member may be a projection formed under the pixel electrode, and the second area divided member may be an opening formed in the pixel electrode.

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown.

FIG. 1 is a layout view of an LCD panel according to a first embodiment of the present invention and FIG. 2 is a sectional view taken along line II-II' in FIG. 1.

A plurality of gate lines 20 extending in a transverse direction and X-shaped projection members 21 made of the same material as the gate lines 20 are formed on an insulating substrate 10. A gate insulating film 30 covers both the gate lines 20 and the X-shaped projection members 21. A plurality of data lines 60 extending in the longitudinal direction are formed on the gate insulating film 30. A passivation film 70 is formed on the data lines 60, and a pixel electrode 80 is formed on the passivation film 70.

One pixel electrode 80 is located in a pixel area defined by the intersections of the two adjacent gate lines 60 and the two adjacent data lines 20. The pixel electrode 80 has openings 81 extending in the transverse direction and X-shaped projection members 71. The X-shaped projection members 71 are formed by the X-shaped member 21 thereunder, and portions of the gate insulating film 30 and the passivation film 70 on the member 21.

The openings 81 are formed in portions which divide the pixel electrodes 80 into three rectangular portions, each X-shaped projection member 71 lies in the respective portion which

the rectangular portion into four areas.

Since the gate insulating film 30 and the passivation film 70 are also located on the gate lines 20 and the data lines 60, the layered structure on the wires 20 and 60 acts as peripheral projections of the pixel electrode 80. Each area enclosed by the projections 71, the openings 81 and the peripheral projections is in a shape of equilateral trapezoid. The areas may be defined as the areas where the pixel electrode 80 is in direct contact with the substrate 10. That is, each area has a planar shape of triangle, of which corner at the center of X-shape is chamfered.

This structure causes a splay arrangement or a bend arrangement of the liquid crystal molecules in each domain, which is defined as a portion of the liquid crystal layer over each divided area, to be reinforced to improve the response time. K_1 (coefficient of splay elasticity) of the splay arrangement or K_3 (coefficient of bent elasticity) of the bent arrangement is greater than K_2 (coefficient of twist elasticity) of the twist arrangement [K_2 (twist) $\leq$ K_1 (splay), K_2 (twist) $\leq$ K_3 (bent)]. Accordingly, the response time of the splay or bent arrangement is smaller than that of the twist arrangement, improving the response time.

FIG. 3 is a layout view of an LCD panel according to a second embodiment of the present invention, and FIG. 4 is a sectional view taken along line IV-IV' in FIG. 3.

A plurality of gate lines 20 extending in a transverse direction and X-shaped projection members 21 made of the same material as the gate lines 20 are formed on an insulating substrate 10. A gate insulating film 30 covers both the gate lines 20 and the X-shaped projection members 21. A plurality of data lines 60 extending in the longitudinal direction are formed on the gate insulating film 30. A passivation film 70 is formed on the data lines 60, and a pixel electrode 80 is formed on the passivation film 70.

One pixel electrode 80 is located in a pixel area defined by the intersections of the two adjacent gate lines 60 and the two adjacent data lines 20. The pixel electrode 80 has openings 81 extending in the transverse direction and X-shaped projection members 71. The X-shaped projection members 71 are formed by the X-shaped member 21 thereunder, and portions of the gate insulating film 30 and the passivation film 70 on the member 21.

The openings 81 are formed in portions which divide the pixel electrodes 80 into three rectangular portions, each X-shaped projection member 71 lies in the respective portion which the rectangular portion into four areas.

The X-shaped projection member 71 has the width increasing as goes from the center toward ends, and does not include the rectangular shape which the first embodiment includes. Accordingly, each area enclosed by the projections 71, the openings 81 and the boundaries of the pixel electrode 80 is in a shape of acute triangle, thereby reinforcing the splay arrangement or the bend arrangement near the projections.

FIG. 5 is a layout view of an LCD panel according to a third embodiment of the present invention.

The layered structure of an LCD panel of the third embodiment is almost the same as that of the first embodiment.

The layered structure of an LCD panel of the third embodiment is almost the same as that of the first embodiment.

The third embodiment is different from the first embodiment in that common signal lines 22 connected to X-shaped projection members 21 are provided, and the outlines of a pixel electrode 80 are convexly curved to make the boundary lines of the divided areas to be curved.

Although the Figs of the third embodiment is shown a gate electrode 26, a source electrode 65 and a drain electrode 66 different from the first embodiment, a gate electrode 26, a source electrode 65 and a drain electrode 66 are omitted at Fig 1 of the first embodiment.

In detail, the shape of each portion of the pixel electrode 80 divided by openings 81 is a curved rectangle so that each area, which is in a shape of equilateral trapezoid in FIG. 1, is in a shape of equilateral trapezoid with a curved long side. In addition, X-shaped members 21 protrude out of the apexes of the curved rectangle and so the pixel electrode 80. The long sides of each opening 81 are concave, and the short sides are convex. At least two of the three X-shaped members 21 are connected to each other at the ends thereof, and the common signal line 22 is connected to the connection of the X-shaped members 21. The common signal line 22 extends from the connection toward data lines 60 and is connected to the X-shaped members 21 of the adjacent pixel after intersecting the data lines 60.

FIG. 6 shows an LCD panel according to a fourth embodiment of the present invention.

The layered structure of an LCD panel of the fourth embodiment is almost the same as that of the third embodiment. However, the outlines of a pixel electrode 80 in this embodiment are much curved to make the boundary lines of the divided areas to be circled.

In the above embodiments, both the projections and the openings are provided on the TFT array panel. However, the projections may be provided on a color filter panel opposite to the TFT array panel, and the openings alone may be provided on the TFT array panel. Furthermore, the openings alone may be provided on both the panels. In this case, the planer shapes of the projections or the openings may be the same as those of the first to the fourth embodiments.

FIG. 7 shows transmittance as function of applied voltage and time lapse, respectively, for LCDs according to a conventional technique and the first and the second embodiments of the present invention. FIG. 8 shows time-transmittance characteristics of the LCDs according to a conventional technique and the first and the second embodiments of the present invention.

In FIG. 7, the violet-colored curve, sky blue-colored curve, and blue-colored curve are a

conventional LCD, the first embodiment LCD, and the second embodiment LCD, respectively. Also, the red-colored curve is a modified embodiment LCD where the interior angles of the triangular areas near the center of the X-shaped members are smaller than those of the second embodiment. Although the transmittances of the LCDs according to the present invention are slightly smaller than that of the conventional LCD, they are still satisfactory to displaying images with gray scale.

In FIG 8, the deep blue-colored curve, the violet-colored curve, and the baby blue-colored curve are a conventional LCD, the first embodiment LCD, and the second embodiment LCD, respectively. Also, the sky blue-colored curve is a modified embodiment LCD where the interior angles of the triangular areas near the center of the X-shaped members are smaller than those of the second embodiment. The LCDs according to the present invention are flatter than the conventional technique as shown in FIG.8.

The following table 1 shows the response time of the above-described LCDs of the present invention compared with the conventional technique.

[table 1]

	T_{on}	T_{off}	T_{total}
Conventional technique	31.6	13.8	45.4
The first Embodiment	21.3	14.4	35.7
The second Embodiment	27.2	14.7	41.9
The modified Second Embodiment	29.7	14.3	44.0

As shown in Table 1, the response time of the LCDs of the present invention is shorter than that of the conventional technique. As described above, the improved response time of the present invention results from the reinforcement of the splay and the bend arrangements.

FIG. 9a shows a matrix of pixels when the distance between a data line and a pixel electrode is 5 ㎛, and FIG. 9b shows a matrix of pixels when the distance between a data line and a pixel electrode is 10㎛.

As shown in the figures, an amount of brush or texture in the case of 10㎛ distance is smaller than that in the case of 5㎛ distance. That is, as the distance between the pixel electrodes increases, the alignment of the liquid crystal molecules becomes stable, thereby diminishing brush or texture.

[EFFECT OF THE INVENTION]

The present invention reinforces the bend and the splay arrangement of the liquid crystal molecules so as to improve the response time.

While the present invention has been described in detail with reference to the preferred embodiments, those skilled in the art will appreciate that various modifications and substitutions can be made thereto without departing from the spirit and scope of the present invention as set forth in the appended claims.

[CLAIMS]

1. A liquid crystal display panel comprising:
an insulating substrate,
a pixel electrode formed on the substrate and having a plurality of openings, and
X-shaped projections formed on the substrate,
wherein an area divided by the X-shaped projections, the openings, and boundary of the pixel electrode has a planar shape that a corner at the center of X-shape of the first area divided member is chamfered.

2. The liquid crystal display panel of claim 1, wherein the opposite sides of the chambered corner are convex.

3. The liquid crystal display panel of claim 2, wherein the opposite side forms a circle when the radius of curvature of the opposite sides is extended.

4. A liquid crystal display panel comprising:
an insulating substrate,
a pixel electrode formed on the substrate and having a plurality of openings, and
X-shaped projections formed on the substrate,
wherein an area divided by the X-shaped projections, the openings, and boundary of the pixel electrode has a planar shape of acute angle.

5. The liquid crystal display panel of claim 1 or 4, wherein the X-shaped projections are positioned under the pixel electrode and a surface of the pixel electrode is protruded by the projections.

6. A liquid crystal display panel comprising:
a first substrate,
a pixel electrode on the first substrate,
a second substrate facing the first substrate,
a common electrode on the second substrate,

a first area divided member formed on at least one of the first substrate and the second substrate and having X shape, and

a second area divided member formed on at least one of the first substrate and the second substrate,

wherein an area divided by the first area divided member, the second area divided member, and boundary of the pixel electrode has a planar shape that corner at the center of X-shape of the first area divided member is chamfered.

7. A liquid crystal display panel comprising:

a first substrate,

a pixel electrode on the first substrate,

a second substrate facing the first substrate,

a common electrode on the second substrate,

a first area divided member formed on at least one of the first substrate and the second substrate and having X shape, and

a second area divided member formed on at least one of the first substrate and the second substrate,

wherein an area divided by the first area divided member, the second area divided member, and boundary of the pixel electrode has a planar shape of acute angle.

8. The liquid crystal display panel of claim 6 or 7,

wherein the first area divided member is formed on the second substrate and has a projection shape, and

the second area divided member is an opening formed in the pixel electrode.

9. The liquid crystal display panel of claim 6 or 7, wherein the first area divided member and the second area divided member are openings formed in the pixel electrode and the common electrode, respectively.

10. The liquid crystal display panel of claim 6 or 7, wherein the first area divided member and the second area divided member are formed on the first substrate, the first area divided member is a projection formed under the pixel electrode, and the second area divided member is an opening formed in the pixel electrode.